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Eng 8-660

OC 7745

Director of Logistics

PLEASE RETURN TO ENGINEERING DIVISION

11 JUN 1958

Director of Communications

Contract RD-138, [redacted] 25X1

1. This Office has a requirement for the development of a miniaturized hand-crank generator which can be used for recharging storage batteries. Several agent battery powered communication systems are under development which may use such a generator to great advantage.

2. Proposals for the development of this equipment have been received and carefully examined. The technical proposal and cost quotation submitted by [redacted] 25X1 has been found acceptable. This company 25X1 is considered well qualified to undertake this task. Your Office has advised that Task Order 4 under base contract RD-138 would be available for assignment to this project.

3. It is requested that Task Order 4 be written to incorporate the attached contractors proposal and Agency Specification No. 58-A-1071-A. Also attached is Requisition No. MSB 58-539 indicating that the allotment to be charged for this work is 8/7995-50. Funds in the amount of $78,064.19 have been encumbered for this project.

4. The work to be performed under this task is UNCLASSIFIED, however, the association of the Agency with the project and the contractor is classified SECRET. The project engineer for this task will be [redacted] 25X1

SIGNED

[redacted] 25X1

Attachments:

1) Requisition No. MSB 58-539
2) Technical Proposal and Cost and Analysis
3) Specification No. 58-A-1071-A

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TECHNICAL PROPOSAL

for the

DEVELOPMENT

of a

BATTERY CHARGING HANDCRANK GENERATOR, HG-3

Specification No. 58-A1071-A

Dated 8 May 1958

June 2, 1958

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TECHNICAL PROPOSAL

for the

DEVELOPMENT

of a

BATTERY CHARGING HANDCRANK GENERATOR, HG-3

Specification No. 58-A1071-A
Dated 8 May 1958

SECTION A.

SUMMARY

It is desired to design and build a hand crank generator with a regulated 15 watt output which will fit in a space 8" x 2" x 4" and weigh not more than 8 lbs.

Such a generator is feasible, and one possible construction is described in this proposal. Basically the machine outlined herein is a two winding AC generator with a six pole permanent magnet rotor, coupled to a full wave rectifier (in place of a commutator) to convert the generated AC to the desired DC. The output of the machine is controlled by a constant current-constant power regulator.

It is the contractor's interpretation of the specifications that the equipment desired should be considerably advanced beyond present types. The efficiency of present, hand cranked generators, is in the neighborhood of 60%. The power source must deliver 25 watts to produce 15. This does not seem a desirable situation when it is remembered that the present source of power is a human being and that he must drive this particular generator for extended periods of time. Emphasis has been placed in this proposal, therefore, on developing a machine with much greater efficiency - say 90% efficient - to reduce the "load" on the operator to a more comfortable point. This will involve extensive engineering study and calculations to realize the maximum efficiency in the design. It will also necessitate ingenuity on the part of the mechanical and electrical designers.

Every element of the machine will be studied from an efficiency standpoint. For example, it is possible to build the required regulator in a more or less conventional manner, using semi-conductors. One such arrangement is described in this proposal. However, there is a second, more interesting possibility, also described herein. The regulator could include magnetic amplifier elements which would act to prevent

excess power from being put into the machine; rather than merely dissipating excess power as would the semi-conductor arrangement. The magnetic amplifier device actually limits the amount of power which the operator can deliver to the machine. The faster he cranks, the lower is the resisting torque. The efficiency of the generator would be improved by such a non-dissipative regulator. Magnetic amplifiers are larger than semi-conductors, however, and it will require more effort to fit this type of control into the available package than to fit in the conventional regulator. It can be done, however, and it is effort of this type which will produce the desired high-efficiency machine.

A DISCUSSION OF THE SPECIFICATIONS AND OF THEIR FEASIBILITY WITH PROPOSED SOLUTIONS FOR SPECIFIC PROBLEMS

SECTION B

B-1 General Discussion

It is desired to produce a hand crank generator with a 15-watt output which will fit in a space 8" x 4" x 2" and weigh not more than 8 lbs.

It seems practical to build a generator which will meet these broad specifications. In existing electrical machinery a typical 1/50 HP D.C. motor complete with worm gear reduction weighs 6 lbs., and falls into this area. The novel elements which would be required in this generator would be: the motor, the regulator, and the rectifier, andnone of these are large or heavy. The case in which all of these are mounted will, of course, be a little larger than of that of a standard motor but in any event, this much power in this size package for this weight does seem reasonable.

It also seems possible for a human operator to drive a machine which has a 15-watt output for extended periods of time, particularly if effort is expended to engineer the device for maximum possible efficiency. If we assume an overall efficiency for the machine of, say, 75% including mechanical and electrical losses, the operator will be required to put approximately 23 watts of power into the machine (about 1/30 HP). Actually a higher rate of work would be possible from a human but the lower rate will, of course, allow for a more or less continuous operation over an extended period.

The solution to any engineering problem is usually a careful compromise. For example, in this machine it would be nice to have a high rotor speed because this would reduce the core and coil size. However, a high rotor speed means an increase in the complexity of the drive mechanism. Furthermore, the overall efficiency of the machine will be a function of both mechanical and electrical losses. Increasing the speed may reduce electrical losses but at the same time increase mechanical losses in the drive. Also, increasing the number of poles on the permanent magnet would reduce the rotor speed, but this means a reduction in cross-sectional area of the magnetic core with a resultant loss of flux. All of these and many other design factors must be manipulated to obtain the optimum design with maximum efficiency.

The calculations on which the rest of this proposal are based are, because of time limitations, merely approximate. However, they should serve first to indicate that this job is feasible and second, to outline a possible configuration. Hand crank generators of the past have required considerable effort and have generally been bulky. It is the feeling of this laboratory that this development should be directed toward a compact easy working device. Such refinement calls for considerable engineering effort and such effort is contemplated in this proposal.

B-2 Power Output

7/25/58 Notified not to be concerned with charging 12 cell Nicd batteries. 25X1

The generator is to be used to recharge 10 and 12 cell nickel cadmium batteries and 6-cell lead acid batteries. This means that it shall be capable of delivering a charging current essentially constant at 1 ampere. The output voltage shall be variable with crank speed within a 60-100 rpm. range. The ratio of peak voltage to A.C. voltage shall be less than 1.5 under all operating conditions.

It is practicable to get a 15-watt generator into an 8" x 4" x 2" package. A sketch of one possible generator layout is shown in Figure A. This sketch does not show the regulator, meter, or drive mechanism; it merely shows the generating elements themselves. However, as will be seen later, the additional apparatus is not very large, and the space not used for the generating elements should be sufficient for the remainder of the mechanism. It should be pointed out that the proposed generator is an AC machine, and that its output is converted to DC by rectifiers to eliminate the wear and mechanical loss problems encountered with a commutator, as well as to reduce the radiated electro-magnetic noise.

The generator shown in Figure A uses a high quality permanent magnet material, such as Alnico V, and approximately 500 turns of wire on each of two stationary windings. It will deliver an alternating voltage waveform with a peak-to-peak amplitude of 44 volts at a crank speed of 60 rpm. and a corresponding higher voltage at higher speeds. From the generator windings, this voltage is passed through a full wave silicon diode rectifier bridge. The output of the rectifier is a pulsating D.C. waveform with a peak-to-average ratio of less than 1.5. No further filtering, therefore, will be necessary. The output from the rectifier will, in turn, be fed to a regulator, which will be described below.

The rotor for this generator is a long 6-pole permanent magnet. A multipole magnet is suggested to reduce the required rotor speed and thereby simplify the drive gear mechanism. Even with a 6-pole magnet, however, a gear ratio on the order of 14 or 15 to one will be necessary between the crank shaft and the rotor shaft. The use of lightweight plastic or ceramic magnets will be considered, but it does not appear as if they would do the job in the space available.

As mentioned above, there is no commutator used in this machine; the full wave rectifier replaces the conventional commutator. This gives two distinct advantages. One, mechanical friction and wear (and resulting losses) are reduced. Number two, the use of a commutator distorts the output waveform from the generator, introducing the high frequency components which could cause radiated electromagnetic noise. Replacing the commutator with a full wave rectifier gives a purer sine wave output and a corresponding decrease in radiated noise. The high efficiency of present day silicon rectifiers makes such an arrangement practical.

B-3 Regulation

The generator shall provide unregulated power up to the 15-watt point, beyond this point the regulating device shall act to prevent power output in excess of rated capacity of the generator.

It is definitely feasible to furnish a regulator in the space available here. A look at Figure A shows that some 2" x 3½" x 4" of space are available beyond that required by the rotating magnet, coils, core structure, etc. This remaining space will be occupied by a regulator, a meter, the rectifier, etc. The rectifier, being made of semi-conductors, will be very small; the meter can be a small sub-miniature one. Most of this space, then, is available for a regulator. One possible regulator described below uses semi-conductors and would fit easily into the space remaining. A second regulator, which will also be described, uses saturable reactor elements and would be larger. However, it is definitely worth considering because of the inherent advantages it gives us and the subsequent increase in efficiency.

System A - Figure B shows a schematic of System A and a block diagram of the entire machine incorporating this particular regulator. Figure C shows an output characteristic curve of this regulator. This system is felt to be in line with the intent of the specification, and combines a minimum of components with a fairly simple mode of operation. It operates as follows:

For output voltages up to 15 VDCm transistor #1 is in a non-conducting state since the 15 v. Zener diode keeps bias resistor R_1 at essentially zero potential. Transistor #2, therefore is biased only by diode D_1, which, in turn, is biased sufficiently by R_2 to have a practically constant forward drop at all rectifier output voltages.. R_3 is picked to allow transistor #2 to pass approximately one ampere at all voltages up to 15 v. output. As the output voltage increases beyond 15 v. (due to a higher cranking rate), voltage builds up on R_1 "turning on" transistor #1 and causing a drop in R_3 in such a direction to bias off transistor #2. This reduces the current passed by transistor #2 and thus gives approximately constant power at voltages higher than 15 v.

For rectifier output voltages considerably above 17 VDC, the regulator output voltage will be held down by the battery capability and, therefore, the power output curve of the system will drop off rapidly as shown in Figure C. In such cases, transistor #2, being, in effect, a variable impedance, has the difference between regulator input and output voltages dropped across its emitter-collector circuit, and dissipates the excess power.

The rectifier D_2 acts to prohibit current feedback during periods of operator rest. The pushbutton shown functions to connect the dual-function meter from a normal series-connected position to read charging current to a connection in parallel with the battery terminals, (breaking the line) to read battery voltage.

Sys B

The regulator just described would be very small and compact. The second possible method of regulation to be described uses a magnetic amplifier, the output of which is coupled through a filter to a current and power regulator. This system, which will be called System B, is shown in block diagram and schematic in the Figure D. Its output characteristic is shown in Figure E. The main purpose of the magnetic amplifier, in System B, is to maintain the D.C. voltage into the regulator at a constant level of approximately 17 volts for cranking speeds which would otherwise deliver higher voltage. Since a magnetic amplifier does not dissipate power, this means that the mechanical watts into the generator supplied by the operator, stays essentially constant at cranking speeds over 60 rpm. Its operation is as follows:

The magnetic amplifier is basically a full-wave Ramey-type circuit with transistor #1 acting as the control element. Diodes D_1 and D_2 are Zener diodes with a voltage rating such that for filter output voltages up to 17 v. D.C., all of E_1 and E_2 is across D_1 and D_2 and transistor #1 is biased "off"; that is, the non-conducting state. Therefore, no reset current flows through the saturable reactors SR_1 and SR_2 and they saturate after the first half cycle of generator voltage resulting in the voltage pattern E_3. Current for voltages up to 17 VDC is held at approximately one amp. by transistor #2, as explained in the previous paragraphs.

For generated voltages corresponding to filter output voltages higher than 17 VDC, the diodes D_1 and D_2 "spill over" and allow R_1 and R_2 to bias transistor #1 to a conducting state. Therefore, reset current is allowed to flow and (although the amplitude of the output voltage increases), the duty cycle is reduced. The net result is that the filter output voltage is approximate constant. In essence, then, higher crank speeds cause a resetting condition which prohibits increased power delivery. The constant horsepower input feature allows the operator's average torque requirement to be lowered when he cranks faster. This is due to the decreased duty cycle of the current through the generator windings.

The merits of the two regulation systems described above depend upon the relative importance of the factors of size, simplicity, efficiency, and input power required. The first system is simple, might possibly be made smaller than the required dimensions, but dissipates the excess power at high cranking speeds across the series transistor. The latter method matches the operator's speed to the load automatically, allowing high efficiency at all cranking speeds. This requires some added complexity.

This means that this second system matches the load of the generator to the "output impedance" of the operator whether he be large or small or prefers to crank more slowly at higher torques or more rapidly at reduced torques.

A word should be said about the use of 17 volts as the control point in the regulators rather than 15 volts. The regulators are designed to limit the current output to one amp. up to 15 volts, and then to limit the power output at 15 watts up through 17 volts. The reasons 17 volts was chosen is that available literature would indicate that nickel cadmium batteries have a charging voltage requirement of 1.42 volts per cell. As this generator is designed to charge a 12-cell Ni-Cad battery, 17 volts would be required, and these regulators are designed accordingly. If desired, the 17 volts could be reduced to 15, of course, by a change in the circuit parameters.

B-4 Intermittent Operation

It is specified that the battery will not discharge through the generator when the operator is resting.

It is possible to satisfy this specification without prolonging the actual charging time required.

The discharging of the battery through the generator shall be prevented by the use of semi-conductor diodes shown in Figures B and D. These rectifiers have a very high back resistance and a very low forward voltage drop.

B-5 Indication of Charging Rate

The specifications say that the machine should include a meter with a suitable push button so that the charging current and state of charge of the battery can be clearly seen by the operator.

The only problems involved in including a meter in this machine are those problems arising from restrictions on space. However, it is felt that a meter can definitely be included.

The connections of the meter with the suitable switching are shown in Figures B or D. The push button, when released, will indicate magnitude of the charging current in the battery. When pushed, the meter will be connected as a volt meter, and the terminal voltage of the battery will be indicated. A standard subminiature meter movement will probably be used.

B-6 Size

The dimensions of the machine should be no more than 8" in length, 4" in height, and 2" in width.

A generator can be made in the desired size since electrical machinery of this order of power has dimensions similar to those desired. A special design will obviously be necessary here however, particularly to bring up the electro-mechanical efficiency from the usual 60% to close to 90%.

The electrical factors affecting size have been discussed earlier in this report. They include, it will be remembered, such things as the number of poles on the permanent magnet, the speed of the rotor, the cross-sectional area of the core, the complexity of the gear train, etc. These factors will all have to be juggled to produce the desired package. The rough calculations indicate, however, that the thing can be done. It will take a careful and thorough design study to decide just how much space will be taken by the various machine elements. Perhaps the only questionable feature would be the magnetic amplifier regulator. This has iron core elements and it may be difficult to fit them into the package along with the necessary generating elements. Of course the generator itself could be reduced in size by driving the rotor at a higher speed, if this doesn't result in too much complexity in the drive mechanism.

B-7 Weight

The generator shall weigh no more than 8 lbs.

This is possible; no weight analysis has been made of the design suggestions made in this paper. However, a catalog before the writer shows that a typical 1/50 HP motor weights 6 lbs., complete with a bulky-looking worm gear reduction. The machine we are contemplating would have additional weight in the form of a small motor, the regulator, and the rectifier. The meter and the rectifier are both very lightweight, and the regulator can be light if necessary by using System A, (the semi-conductor system). If space and weight permits the regulator would be made a little heavier by the use of magnetic amplifiers, but even this should not increase the weight 2 lbs. over that of the standard motor. The 8 lbs. definitely seems to be feasible.

B-8 Drive Mechanism

The hand crank must be coupled to the rotor through suitable gearing so that the operator needs to turn the crank only at the relatively slow speed of 60 to 100 rpm.

It is feasible to connect the rotor to the hand crank with gearing which will be simple enough to fit into the space available. The final configuration of the drive mechanism, as has been mentioned earlier, will depend to a large extent on the rotor speed. The higher the speed, the more complex the drive. It is hoped that the speed of the rotor and the drive complexity can be kept down to reduce mechanical losses in the gearing and the bulk of the gear train.

The drive mechanism must be rugged, have long life, be noise-free, be compact and efficient. If the required gear ratio is on the order of 14:1, as suggested earlier, this mechanism might be a simple spur gear train. However, if a much higher ratio becomes desirable, such things as planetary gears or spiroid gears will have to be considered. It is hoped that these can be avoided because of the inherent mechanical losses.

Our work with a small hand driven pump for another client would indicate that a very short radius crank is quite comfortable for prolonged operation; more comfortable, in fact, than a crank so long that the entire arm has to move. A pure wrist motion seems to be less tiring than an arm motion. If a wrist motion crank is adopted, it might be possible to mount the cranking handle on the periphery of a 3" or 4" diameter gear and use the crank handle as the first gear in the reduction train. As the cross-section of the end of the generator is only 2" x 4", this 4" diameter gear would have to be removable and mounted on the side of the generator for storage and carrying.

B-9 Radiated Noise

Electro-magnetic noise radiation shall be kept to a minimum. The device shall be undetectable at a distance of 10 feet by a radio receiver with a 10 microvolts sensitivity at a .5 to 30. megacycles frequency coverage.

This requirement is practical for reasons described below.

Radiated noise should be very low with the device described above. Essentially we have an A.C. permanent magnetic generator producing a low frequency sine wave. No commutators or brushes are to be used but rather the A.C. will be rectified to produce the desired D.C. The output will be a low frequency rectified sine wave. The lack of high frequency harmonics in such a low frequency sine wave will all but eliminate radiated noise. This would not be the case if commutators were used in the machine as the making and breaking of circuits distorts the sine wave output, thereby generating high frequency harmonics which are more readily radiated than are the lower frequencies. (Incidentally, it will not be possible to generate a pure sine wave here as this would give a peak to average ratio greater than 1.5. The amount of distortion necessary to give the correct ratio is slight.)

B-10 Acoustic Noise

Acoustic noise produced by the generator shall be less than a sound level of 50 db. as measured with a sound level meter with 40 db. weighting in a room having an ambient noise level of not more than 40 db. The measurements shall be made at a distance of 3 feet from the top front edge of the generator (10^{-16} acoustic watts per square centimeter shall be taken as the 0 db. reference level).

There seem to be no good reasons why a generator can't be made which will satisfy these requirements.

The main sources of acoustic noise will be the rotor bearings and the drive mechanism. Once again, the use of a multi-polar permanent magnet will reduce the speed of the rotor and therefore the complexity of the drive. Reducing the number and complexity of parts here, in turn, will reduce the noise. It is not felt that shock mountings will be necessary but care will, of course, have to be taken with the bearings and general frame construction to insure quiet operation.

B-11 Temperature Rise During Operation

Prolonged operation of the generator should not produce temperatures which would injure components of the machine.

This specification is definitely feasible.

High temperature rise would indicate a low efficiency in the machine. It is felt that the machine can be made quite efficient by correct electrical and mechanical design. Furthermore, components which would be easily damaged by high temperatures will be avoided wherever possible. There should, as a result, be little danger of temperature damage.

B-12 Mounting

It should be possible to mount the machine on such possible bases as a tree, table, post or body.

There is no reason why a clamp can't be devised which would fasten to a flat or round object.

PERSONNEL AND FACILITIES

SECTION C

This laboratory has the facilities and personnel necessary to undertake a project of this sort. We have an electronics group, a mechanical design group, a very well equipped test laboratory, a large model shop, and facilities for job-lot production of complicated mechanisms. Our personnel has had formal training and experience in a wide variety of disciplines. Although our work has been in a number of fields, perhaps the major emphasis has been on electromechanical hardware for military applications. Chief among these has been our work for guided missile applications where lightweight, compactness, and high reliability are essential.

PREVIOUS WORK OF A SIMILAR NATURE

SECTION D

[redacted] has done a good deal of work with rotating electrical machinery. Our vice president, in fact, owned and operated a small company devoted to the construction and repair of electrical motors, generators, etc. before joining the Laboratory. His interest in these devices has continued. Our electronics department and several of our mechanical engineers have also had a good deal of experience with motors and generators. Although the applications for equipment developed in recent projects cannot be revealed, the specifications for some of these machines can be. Recent design projects, therefore, included the following: 25X1

1. 1/4 H.P., 400 cycle, 3-phase motor (Designed, built and produced in small quantities.).

2. A synchronous generator, 5 kilowatt, 400 cycles.

3. A.C. generator, 50 watts, 1000 cycle.

4. 1/10 H.P., 400 cycles, 3-phase motor, (Designed, built and produced in small quantities.).

5. Self-governing turbine generator for aircraft applications. Produced 14,000 watts at a speed of 14,000 rpm.

6. Permanent magnet motor for an elapsed time indicator, 5/8" O.D., 3/8" long, operated on 30 milliamps at 28 volts.

7. D.C. permanent magnet stator motor for a military tape recorder, 1-3/8" square, 7/32" thick, 800 rpm.

8. Regulated torque D.C. motor, permanent magnet field. (U.S. Patent No. 2, 801,352 was issued to the designer of this particular machine.)

Photographs of two generators we have designed and built are found in the appendix.

There have been other projects here in which rotating electrical machinery was designed, and an even larger number in which it has been used. The specific examples mentioned above, however, should be indicative of our abilities in this area.

SCHEDULING

SECTION E

It is estimated that this project can be completed in one year as follows:

The first four months will be spent on preliminary design and breadboarding. During this period the various design parameters, such as rotor speed, gear train construction, number of poles on the magnet, size of core, etc. will be juggled for optimum efficiency. The two regulators suggested earlier in this proposal will be breadboarded and studied from a performance and size standpoint. In brief, all necessary tests and calculations will be made to determine all the design data needed for a production design.

The second four months will be spent building the first model. This phase will include making a detailed set of drawings, building a model, testing the model, and making revisions in it where necessary. This model will then be given to the client.

Upon the acceptance of the first model by the client, work will begin on phase three - the construction of nine additional generators. This step will include making any engineering changes requested by the client. The delivery of these nine models, plus the required sets of drawings, will complete the project.

CHKD. BY........ DATE .... JOB NO. ....

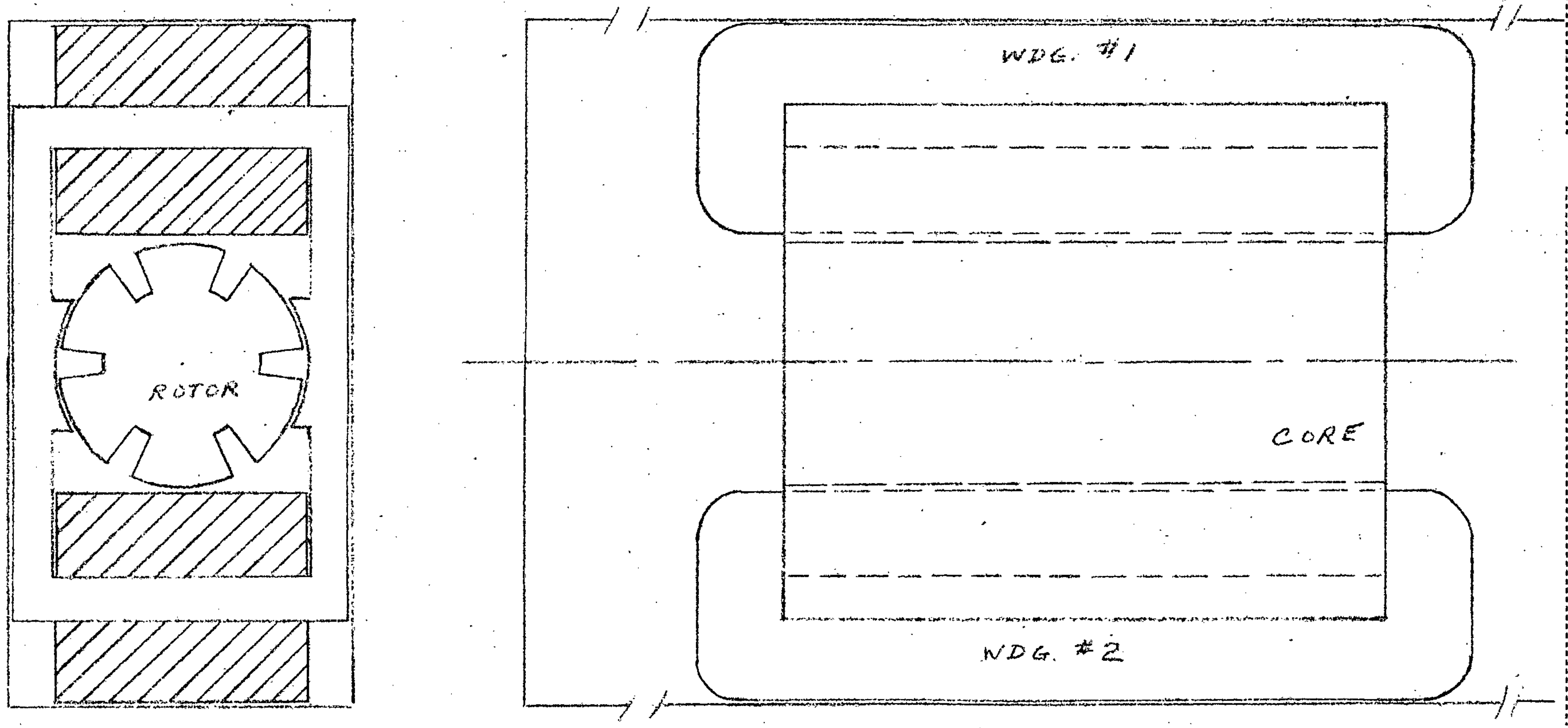

FIG. A LAYOUT OF GENERATOR

(FULL SCALE)

NOTE:
SPACE LEFT FOR
REGULATOR, METER,
DRIVE, ETC IS $2 \times 3\frac{1}{2} \times 4$

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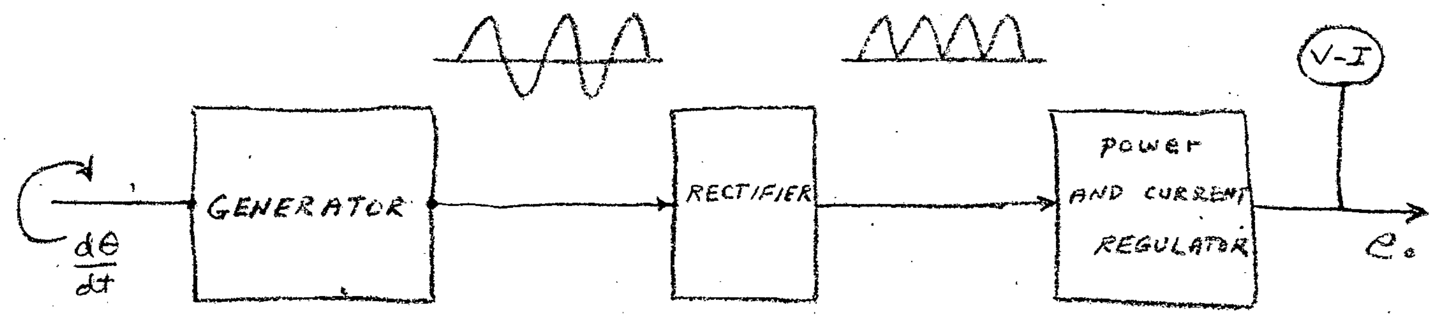

BLOCK DIAGRAM OF SYSTEM A.

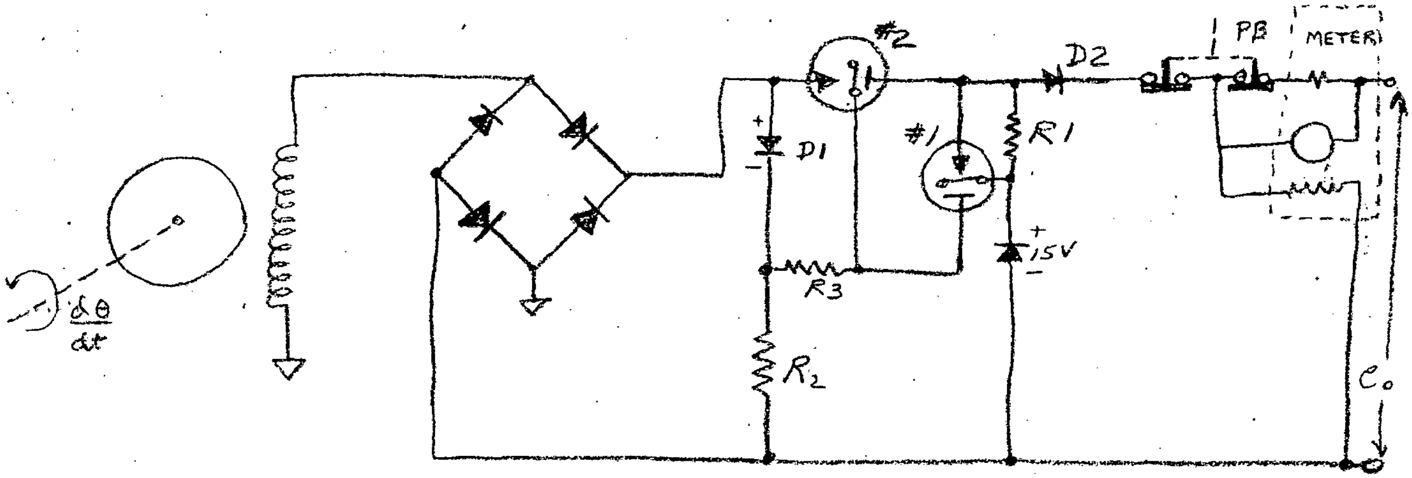

FIG. B - SCHEMATIC OF SYSTEM A.

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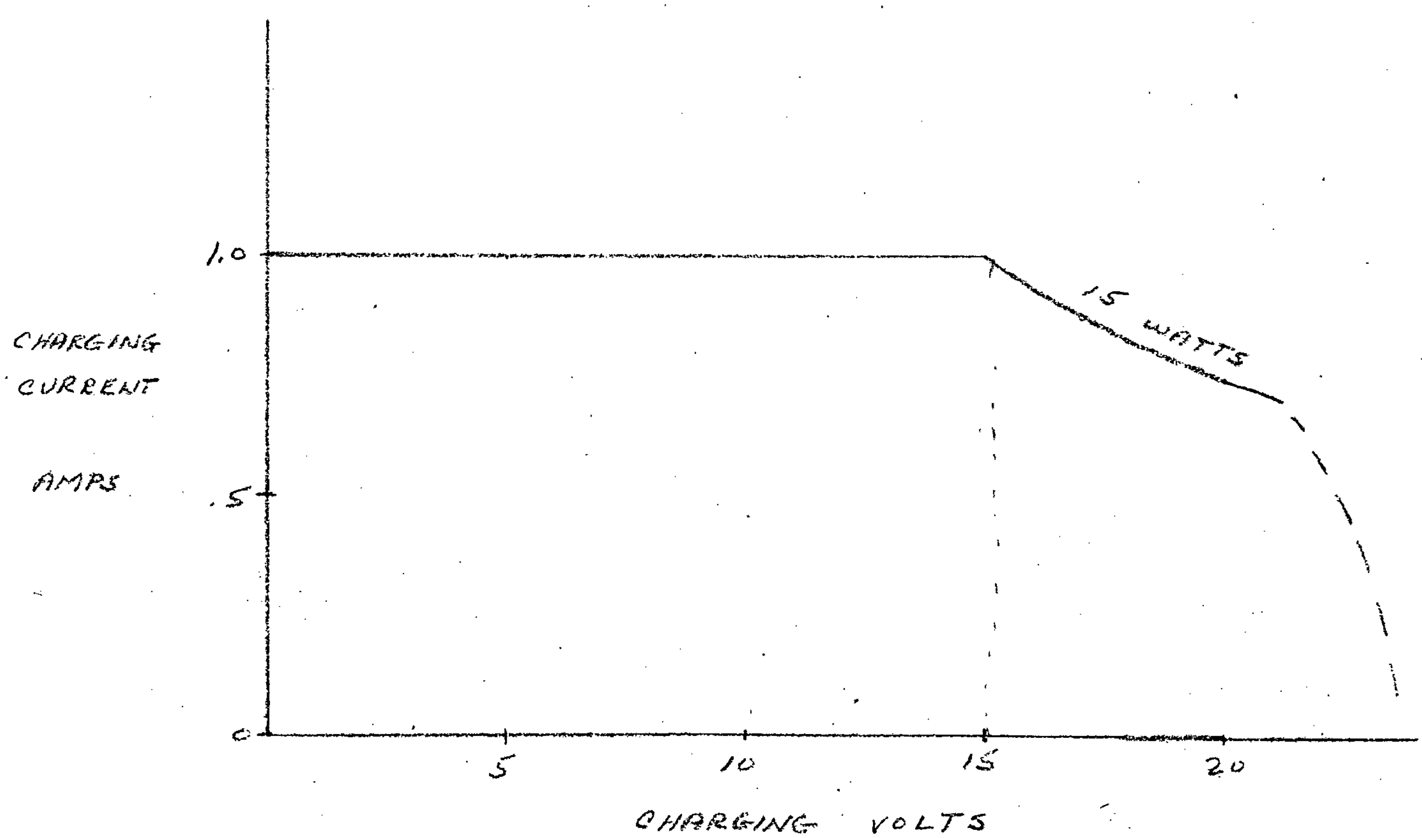
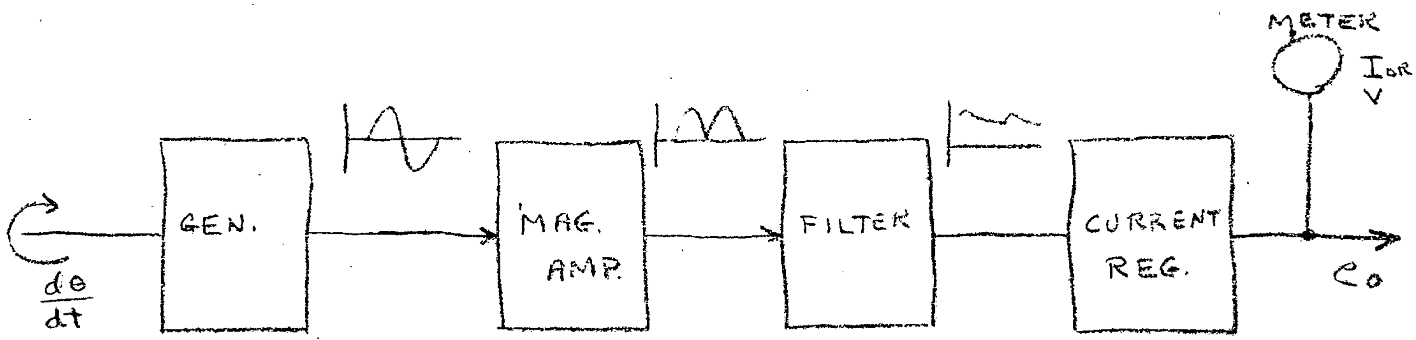


FIG. C OUTPUT CHARACTERISTICS OF SYSTEM A.



BLOCK DIAGRAM FOR SYSTEM B.

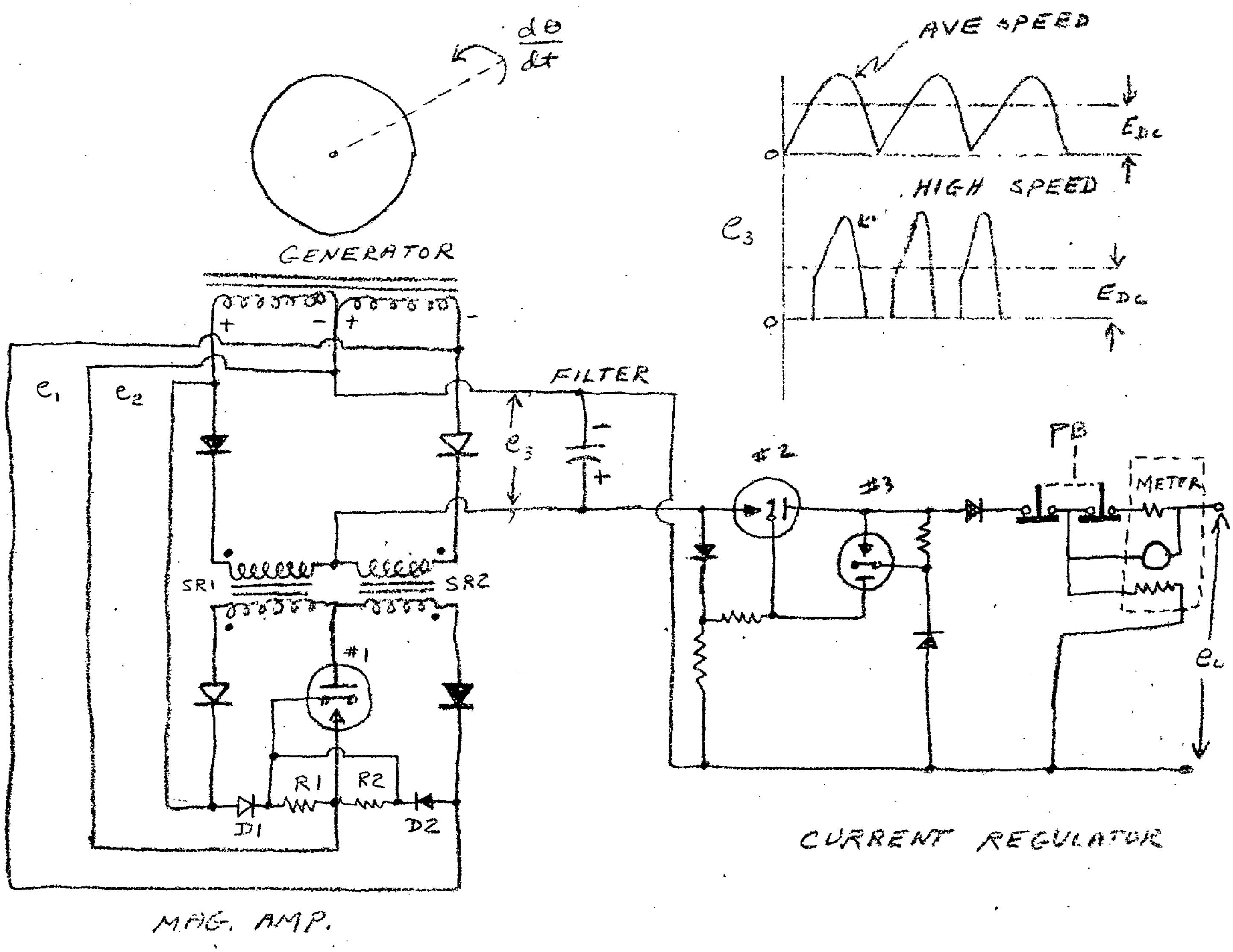


FIG D. SCHEMATIC FOR SYSTEM B.

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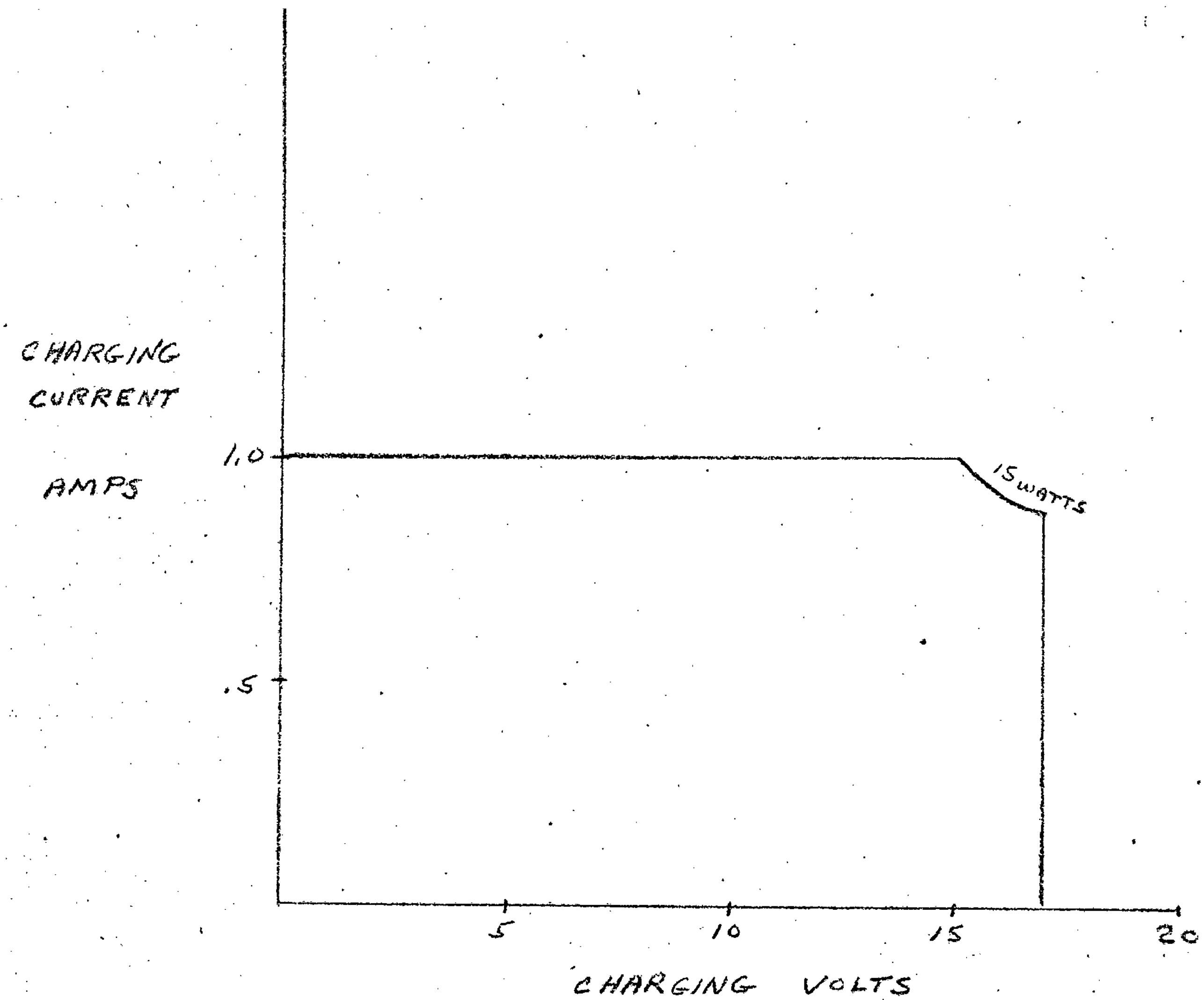

FIG. E OUTPUT CHARACTERISTICS OF SYSTEM B

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Return w/ proposal -

SPECIFICATION NO. 58-A-1071-A

SPECIFICATION FOR THE

DEVELOPMENT OF A BATTERY CHARGING

HANDCRANK GENERATOR, HG-3

6 May 1958

Proposal desired
Prior To 26 May 1959.
Any interest!!

25X1

1. GENERAL

1.1. Scope

This specification stipulates the performance of a battery-charging hand-crank generator and presents electrical and mechanical design characteristics that will aid in the development and production of prototype models of this equipment.

1.2. Description

The product shall consist of the generator, handcrank, all electrical accessories (voltmeter, sockets, cable, clamps, etc.) needed for operation, and universal mounting bracket designed to permit secure attachment to table-top, body, trees, and other possible bases. It shall be operable by one man, turning the crank at an average speed of 80 rpm. The output voltage shall increase with crank speed so that the developed EMF (and subsequent rate of charge) shall depend upon the cranking rate of the operator, the faster charging rates naturally requiring more operator effort. A power output of approximately 15 watts shall be obtainable.

1.3. Nomenclature

The battery-charging hand-crank generator shall be designated as the HG-3.

2. QUALITY OF DESIGN AND FABRICATION

The electrical and mechanical design of the HG-3 shall be directed toward the development of a miniaturized quality product reflecting the highest possible degree of equipment reliability when exposed to the normally rough handling encountered during field usage.

2.1. JAN Specifications

The contractor shall utilize components, materials, and fabrication procedures meeting JAN specifications of the issue in effect on the date of initiation of the contract.

2.1.1. JAN Specification Waiver

To accomplish the desired degree of miniaturization, the contractor may deem it necessary to utilize other than components, materials, and fabrication procedures meeting JAN specification. In such instances, specific waivers may be authorized by the Government but only after review by Government engineers and prior to the submission of any prototype models.

2.2. Non-Fungus Nutrient Materials

All materials used on the generator are to be non-nutrient to fungi. If it is determined that non-nutrient materials are not available and other materials must be used, a waiver may be obtained as in section 2.1.1. Any nutrient material shall be treated by a suitable fungi-resistant compound after machining, or other work, but prior to installation in any unit of the HG-3.

2.3. Environmental Conditions

2.3.1. Operating Temperatures

The design considerations of the generator shall be such as to preclude malfunctioning of the equipment when exposed to operating temperatures of from -40°C to +50°C.

2.3.2. Storage Temperature

The equipment shall be capable of being stored in temperatures within the range of -60°C to +60°C without injurious effects.

2.3.3. Humidity and Salt Spray

Operation or storage in humid or corrosive atmospheres shall not adversely affect the performance of the generator.

2.3.4. Waterproofing

The internal mechanism of the generator shall be suitably sealed so that temporary immersion in water will neither shorten its useful life nor impair the efficiency of operation in any way.

2.3.5. Shock Resistance

The HG-3 shall be of ruggedized construction. Normal shocks and vibration resulting from rough handling and operation in the field shall have no injurious effects upon the mechanism.

2.3.6. Life

The generator shall withstand the life test outlined in 2.3.6.1. for 1000 hours without permanent damage.

2.3.6.1. Life Test

The generator shall be cycled for a period of 1000 hours in the following manner: (1) 30 minutes on, generating at full capacity, and (2) 30 minutes off.

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3. DESIGN CHARACTERISTICS

3.1. General

It is the intent of the Government to obtain a miniaturized hand-crank generator for the specific purpose of quickly and efficiently recharging secondary batteries. It is desired that the finished product be as small and light as possible, but in no case is ruggedness or ease of operation to be sacrificed in attaining these ends. The design ingenuity of the contractor is not to be restricted except in certain cases, wherein the Government may specify preferred configurations.

3.2. Electrical Design Characteristics

7/25/58 [redacted] notified to disregard charging of 12 cell NiCd batteries. G.W.S.

25X1

3.2.1. Charging Voltage

Output DC voltage of the generator shall be variable with crank speed over the entire range needed to efficiently recharge 10 and 12 cell Nickel-Cadmium batteries and 6 cell Lead-Acid batteries. These generator voltages shall be obtainable, while charging at a 1 ampere rate, at crank speeds within a 60-100 rpm range.

3.2.1.1. Voltage Waveform

The ratio of peak voltage to DC voltage shall be less than 1.5 under all operational conditions.

3.2.2. Charging Current

The HG-3 shall be capable of supplying charging currents up to 1 ampere at all charging voltages.

3.2.3. Power Ouput and Regulation

A power output of approximately 15 watts shall be obtainable throughout the charging operation. The electrical design of the generator shall provide unregulated power up to this point. Beyond this point, a regulating device shall act to prevent power outputs in excess of the rated capacity of the generator. Electronic rather than electro-mechanical components shall be used in the power regulating system unless, after thorough investigation by the contractor, it is found that utilization of electro-mechanical units is necessary to assure an efficient, dependable regulator.

3.2.4. Intermittent Operation

Periodic cessations of cranking activity, for operator rest, shall not prolong total actual charging time by allowing the battery to discharge itself through the generator.

3.2.5. Indication of Charging Rate and State-of-Charge

A small, rugged dual-function meter shall be installed in an easily observable location on the generator. A pushbutton located adjacent to the meter shall be used to select the desired function. The circuitry shall be such that while the button is depressed, the meter will indicate terminal voltage of the battery being charged. When the button is released, the meter shall indicate magnitude of the charging current.

3.2.6. Connectors

For electrical connections, a flexible cable shall be supplied with each generator. The cable shall have clips on one end, suitable for attachment to the battery terminals. The other end shall have provision for plugging directly into the generator. Length of the cable shall be 5 feet.

3.3. Mechanical Design Characteristics

3.3.1. External Dimensions and Appearance

3.3.1.1. Shape

Considerations affecting the ultimate shape of the HG-3 shall be:

(1) Maximum miniaturization
(2) Maximum efficiency
(3) Ease of operation
(4) Ease of mounting for operation
(5) Convenience of packaging for transport

3.3.1.2. Size

Overall external dimensions shall be no more than 8" in length, 4" in height, and 2" in width.

3.3.1.3. Weight

The HG-3 shall weigh no more than 8 pounds.

3.3.1.4. Color

The color of the HG-3 shall be a non-reflective dull black.

3.3.2. Crank Design

The crank of the HG-3 shall be easily operable at the generating speeds of 60-100 rpm. It shall fit into a standard 3/8" square socket on the generator chassis, and shall be removable to allow efficient packaging of the generator when not in use. Adaptors to be used for mechanically coupling the generator to such driving power sources as lathes or drill presses shall also be received by the crank socket.

3.3.3. **Drive Mechanism**

The mechanism employed to translate the crank speed of the generator to a suitable rotor speed shall be decided jointly by the contractor and the Government project engineer following a proper investigation of the available methods such as Ball Friction drive, Spiroid Gear drive, Planetary Gear drive, and Ring Gear drive. Design considerations shall be:

(1) Ruggedness
(2) Long operational life
(3) Noise-free operation
(4) Maximum miniaturization
(5) Mechanical efficiency

MIL 16910-A - BU SHIPS
10 ft instead of 3 ft.

3.3.4. **Radiated Noise**

Ref. Army & Navy Spec

Electromagnetic noise radiation shall be minimized. When generating 15 watts of charging power, the HG-3 shall be undetectable at a distance of 10 feet by a radio receiver with a 10 microvolt sensitivity and .5 mc to 30 mc frequency coverage.

3.3.5. **Acoustic Noise**

Audible noise of the HG-3 shall be held to a minimum. The acoustic noise produced by the generator when cranked at a 15 watt charging rate shall be less than a sound level of 50 db when measured as specified in 3.3.5.1.

3.3.5.1. **Acoustic Noise Test**

The acoustic noise due to operation of the generator shall be measured with a sound level meter (type 759-B as manufactured by General Radio Company, or equal) with 40 db weighting, in a room having an ambient noise level of not more than 40 db.

Reference Level, 0 db=10^{-16} watts (acoustic) per sq. cm.

Noise measurements shall be made at a distance of 3 feet from the top front edge of the generator to the center of the sound level meter microphone.

3.3.6. **Temperature Rise During Operation**

Temperature rise of the generator during prolonged operation at rated capacity output shall not be of such a magnitude as might have injurious effects upon components of the generator.

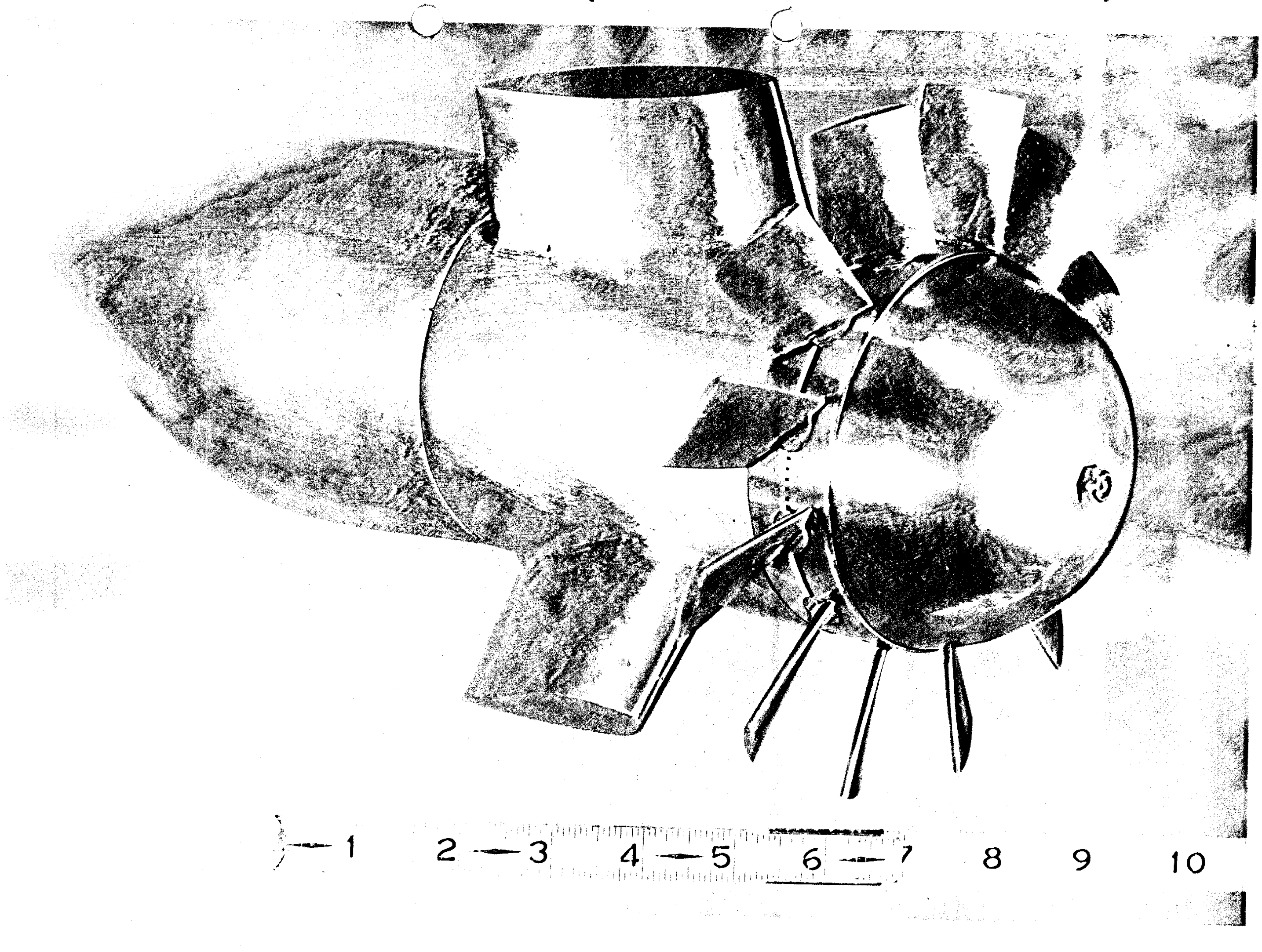
3.3.7. Mounting

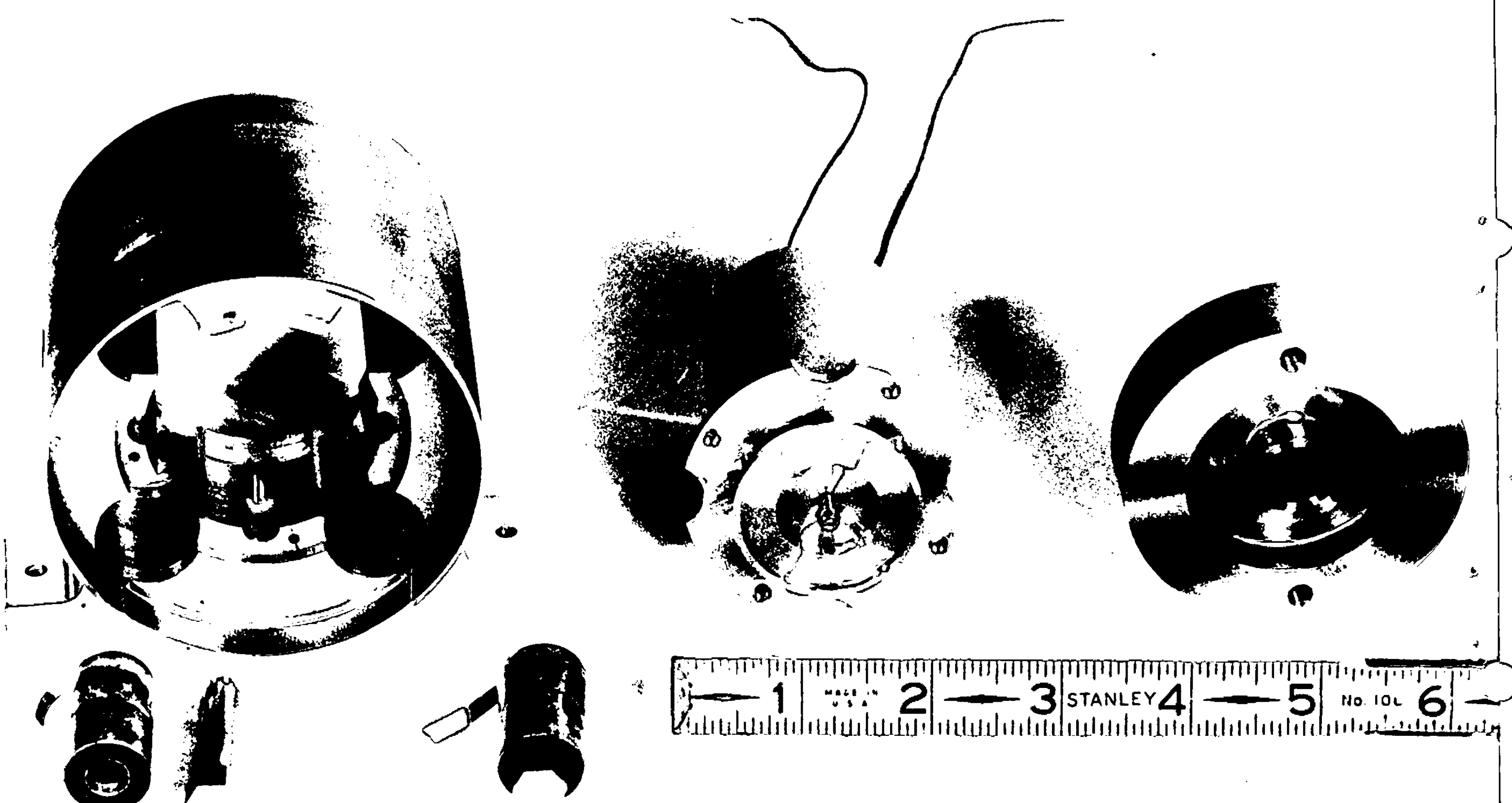
The HG-3 shall have provision for secure mounting on such possible bases as a tree, table, post, or body.

ATTACHMENT "A"

DELIVERABLE ITEMS:

Item 1	Prototype Model, HG-3, complete with accessories One model shall be delivered for Government inspection of design and construction. Fabrication of the remaining 9 models shall commence upon approval of model #1.	10 each
Item 2	Engineering Drawings	
	Reproducible Master set, complete	1 each
	Copies, set, complete	2 each
Item 3	Bi-monthly Engineering Progress Reports These reports shall contain complete data concerning mechanical and electrical design progress of the HG-3. All experiments and tests and the results thereof shall be outlined. Diagrams, sketches and photographs may be included as desired for clarity of description.	5 each
Item 4	Final Engineering Report Prior to or with the delivery of Item 1 above, a final engineering report shall be submitted which summarizes the conclusions reported in each of the bi-monthly reports. Final test data and descriptions of the electrical and mechanical operation shall also be included.	10 each

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